Empirical Assessment of the Demand for Residential Solar Distributed Generation and the Impact of Electricity Rate Design Reform

PRESENTED TO
Rutgers University Center for Research in Regulated Industries

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THE Brattle GROUP
DERs and the Growth of Solar PV

Distributed Energy Resources ("DER") are defined as “behind-the-meter” generation resources and demand-side options relied upon to meet all or a portion of customer’s electric load.

Solar PV Demand

Purchase Solar PV if the price of the system is less than the total lifetime expected discounted benefits.

**Total expected benefits:**

- Reductions in electricity usage from the Local Distribution Company (LDC) and thus lower payments to the LDC
  - ✓ Impact of electricity rate design reform?

- Payments from the utility to the solar PV owner for exporting excess energy back to the distribution grid
  - ✓ Impact of changes to net-metering?

- Intrinsic “value” to the consumer from producing and consuming renewable electricity
Electricity rates are generally “misaligned”

<table>
<thead>
<tr>
<th>Cost categories</th>
<th>Utility’s Costs</th>
<th>Customer’s Bill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable ($/kWh)</td>
<td>Variable = $60</td>
<td>Variable = $115</td>
</tr>
<tr>
<td>- Fuel/gas supply</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Operations &amp; maintenance</td>
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<td></td>
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<tr>
<td>Fixed ($/customer)</td>
<td>Fixed = $10</td>
<td>Fixed = $5</td>
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<tr>
<td>- Metering &amp; billing</td>
<td></td>
<td></td>
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<tr>
<td>- Overhead</td>
<td></td>
<td></td>
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<tr>
<td>Size-related (demand) ($/kW)</td>
<td>Demand = $50</td>
<td></td>
</tr>
<tr>
<td>- Transmission capacity</td>
<td></td>
<td></td>
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<tr>
<td>- Distribution capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Generation capacity</td>
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</tbody>
</table>

What impact may reducing volumetric rates have on solar PV demand?
### Number of installations in sample by state

<table>
<thead>
<tr>
<th>State</th>
<th># Installations</th>
<th># Years with Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>662,886</td>
<td>12</td>
</tr>
<tr>
<td>Arizona</td>
<td>111,391</td>
<td>12</td>
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<tr>
<td>Massachusetts</td>
<td>74,113</td>
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<td>New York</td>
<td>65,909</td>
<td>12</td>
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<td>Colorado</td>
<td>40,919</td>
<td>11</td>
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<tr>
<td>Texas</td>
<td>19,125</td>
<td>12</td>
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<tr>
<td>Connecticut</td>
<td>15,882</td>
<td>7</td>
</tr>
<tr>
<td>New Mexico</td>
<td>6,265</td>
<td>8</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>5,483</td>
<td>8</td>
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<tr>
<td>New Jersey</td>
<td>3,746</td>
<td>7</td>
</tr>
<tr>
<td>Delaware</td>
<td>2,209</td>
<td>12</td>
</tr>
<tr>
<td>Florida</td>
<td>2,157</td>
<td>12</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>2,066</td>
<td>7</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>1,555</td>
<td>10</td>
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<tr>
<td>Minnesota</td>
<td>1,297</td>
<td>10</td>
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<td>Oregon</td>
<td>1,124</td>
<td>10</td>
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<tr>
<td>Arkansas</td>
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Source: PV system data from Lawrence Berkeley National Laboratory (LBNL), Tracking the Sun database, filtering to systems mapped to a utility service territory.
## Top 15 utilities by number of installations in sample

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Pacific Gas &amp; Electric</td>
<td>CA</td>
<td>5,487</td>
<td>5,550</td>
<td>7,365</td>
<td>8,530</td>
<td>11,381</td>
<td>13,607</td>
<td>13,254</td>
<td>3,219</td>
<td>31,424</td>
<td>63,272</td>
<td>52,974</td>
<td>56,744</td>
<td>272,807</td>
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<td>Southern California Edison</td>
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<td>1,893</td>
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<td>4,863</td>
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<td>13,532</td>
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<td>17,356</td>
<td>32,711</td>
<td>50,104</td>
<td>41,533</td>
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<td>755</td>
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<td>2,575</td>
<td>2,930</td>
<td>3,877</td>
<td>3,501</td>
<td>3,643</td>
<td>19,716</td>
<td>27,948</td>
<td>17,165</td>
<td>22,571</td>
<td>107,616</td>
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<td>3,389</td>
<td>5,952</td>
<td>6,598</td>
<td>1,483</td>
<td>71</td>
<td>11,609</td>
<td>18,008</td>
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<td>National Grid</td>
<td>MA</td>
<td>78</td>
<td>113</td>
<td>236</td>
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<td>384</td>
<td>955</td>
<td>1,969</td>
<td>5,031</td>
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<td>12,510</td>
<td>5,601</td>
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<td>1,975</td>
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<td>1,922</td>
<td>3,633</td>
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<td>5,701</td>
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<td>7,334</td>
<td>3,640</td>
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<tr>
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<td>73</td>
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<td>5,699</td>
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<td>20,533</td>
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<td>Salt River Project</td>
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<td>100</td>
<td>646</td>
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<td>City of San Antonio</td>
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<td>2,963</td>
<td>3,014</td>
<td>22</td>
<td>-</td>
<td>10,829</td>
</tr>
</tbody>
</table>

Source: PV system data from LBNL Tracking the Sun database.
% PV Adoption among utilities in sample vs. all utilities

Notes: % PV Adoption calculated from Form EIA-861 data as number of PV customers divided by total residential customers. Sample is defined as utilities for which there is system data in LBNL Tracking the Sun database.
Annual Payback Period (with incentives) across utilities in sample

Notes: Calculated as average over individual utility payback periods, weighted by number of installations. Payback period computed as Total Cost (net of 30% ITC and rebates)/Total Savings, using system data for sample from LBNL Tracking the Sun database. Each observation represents one year between 2008-2018.

Notes: Net cost per watt computed as (installed cost + sales tax cost – rebate – performance-based incentive)/system size, based on LBNL Tracking the Sun database.
**Notes:** Data represents years 2007-2018. PV penetration computed from EIA data as number of residential net metering customers over total residential customers. Net cost per watt computed as (installed cost + sales tax cost – rebate – performance-based incentive)/system size, based on LBNL Tracking the Sun database, which converts all dollars to real 2018 $. 

**Pacific Gas & Electric Co.**
PV Penetration (%) vs. Net Cost (2018 $/Watt)

Notes: Data represents years 2007-2018. PV penetration computed from EIA data as number of residential net metering customers over total residential customers. Net cost per watt computed as (installed cost + sales tax cost – rebate – performance-based incentive)/system size, based on LBNL Tracking the Sun database, which converts all dollars to real 2018 $.
PV Penetration (%) vs. Net Cost (2018 $/Watt)

Notes: Data represents years 2007-2018. PV penetration computed from EIA data as number of residential net metering customers over total residential customers. Net cost per watt computed as (installed cost + sales tax cost – rebate – performance-based incentive)/system size, based on LBNL Tracking the Sun database, which converts all dollars to real 2018 $.
PV Penetration (%) vs. Net Cost (2018 $/Watt)

Arizona Public Service Co

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Notes: Data represents years 2007-2018. PV penetration computed from EIA data as number of residential net metering customers over total residential customers. Net cost per watt computed as (installed cost + sales tax cost − rebate − performance-based incentive)/system size, based on LBNL Tracking the Sun database, which converts all dollars to real 2018 $. 
Solar Penetration vs Average Electricity Price by Utility (2018)

Notes: PV penetration computed from EIA data as number of residential net metering customers over total residential customers. Average electricity prices calculated from Form EIA-861 data as total $ revenues/kWh energy sales.
PV Penetration (%) vs. Average Electricity Price (2018 $/kWh)

PV Penetration (%) vs. Average Electricity Price (2018 $/kWh)

PV Penetration (%) vs. Average Electricity Price (2018 $/kWh)

PV Penetration (%) vs. Average Electricity Price (2018 $/kWh)

PV Penetration (%) vs. Average Electricity Price (2018 \$/kWh)

Solar Penetration vs Average HH Income by Utility (2018)

Notes: Includes 47 utilities with installed systems in 2018. PV penetration from Form EIA-861 data on PV customers and total customers. Weighted average household income calculated from 2017 US Census Bureau data as average over zipcodes included in each utility’s service territory, weighted by number of households (for entire zipcode). Includes 47 utilities with 2018 PV system data in LBNL Tracking the Sun database.